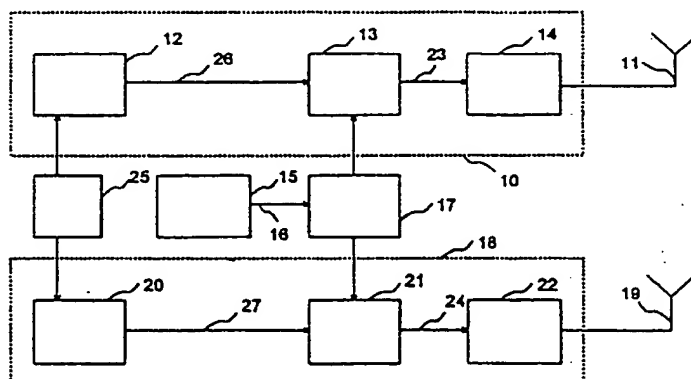




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(54) Title: METHOD FOR REALIZING FREQUENCY HOPPING AND A BASE STATION EQUIPMENT



## (57) Abstract

The invention relates to a base station equipment and a method for implementing frequency hopping in a base station of a digital cellular radio system, in which base station a first signal (23) modulated by a base band data signal (16) is transmitted on a certain carrier frequency (26), which signal is divided in the time domain into several time slots of which one time slot transmits the common control channel (BCCH) of the base station equipment and the other time slots information regarding different connections. For an economical implementation of frequency hopping in a base station comprising one transceiver unit, the base station further transmits a second signal (24) modulated by the same base band data signal (16) on a certain carrier frequency (27), which second signal (24) is divided in the time domain into several time slots, each of which transmits the same information as the first signal (23), except the time slot that transmits the common control channel (BCCH) of the base station equipment, and which carrier frequency (27) is changed time-slot-specifically so that the frequency is the same as the carrier frequency (26) or different than that.

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## Method for realizing frequency hopping and a base station equipment

5 The present invention relates to a method for implementing frequency hopping in a base station of a digital cellular radio system, in which base station a first signal modulated by base band data signal is transmitted on a certain carrier frequency, which signal is divided in the time domain into several time slots of which one time slot transmits the common control channel of the base station equipment and the other time slots information regarding different connections.

10 In cellular radio systems, the quality of a radio channel varies as a function of time and place. On many occasions a transmitting antenna and a receiving antenna are not within sight of each other due to obstacles formed by terrain or buildings in the line of sight, and thus the signal detected at the receiver is a sum of beams that have travelled different paths and have been reflected from obstacles and that are, further, with different phases. The sum of several signals with different phases follows the Rayleigh distribution in cases of randomly distributed phases.

15 Signal fading is, furthermore, dependent on the frequency of the signal. Thus, if a frequency difference between two signals is great enough, their fadings do not correlate. A difference of 1 MHz, for example, is large enough for signal fadings to be independent of each other.

20 The frequency selective fading of a signal described above is one reason for the introduction of frequency hopping technology in digital cellular radio networks. Frequency hopping means that the transmission frequency used in a connection is changed at predetermined intervals. Due to frequency hopping, the

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transmission quality can be improved especially in situations in which the terminal equipment moves very slowly or not at all as is often the case with, for example, hand-held phones.

5           Apart from the frequency diversity achieved by frequency hopping, the method is also advantageous in distributing the interferece caused by the radio connection onto several frequencies, in which case momentary interference on any one frequency will remain  
10           small.

          In the prior art solutions, if frequency hopping has been desired in a cell served by a base station, the base station equipment must have been provided with at least two complete transceiver units  
15           which contain base band sections and radio frequency sections. Each unit as such can form an independent base station, but to implement frequency hopping several of them have been required in the same cell. This has resulted in that the base station equipment capable of  
20           frequency hopping has been disproportionately large in small cells in comparison with the capacity needed, and the implementation of frequency hopping has thus required heavy investments.

          It is thus an object of the present invention  
25           to implement frequency hopping in a base station equipment economically and without creating excessive capacity.

          This is achieved with the method of the type set forth in the introduction, which is characterized  
30           in that the base station further transmits a second signal modulated by the same base band data signal on a certain carrier frequency, which second signal is divided in the time domain into several time slots, each of which transmits the same information as the first  
35           signal, except the time slot which transmits the common

control channel of the base band equipment, and which carrier frequency is changed time-slot-specifically so that the frequency is either the same as the carrier frequency or different than that.

5           The invention also relates to a base station equipment in a digital cellular radio system, said equipment comprising means for generating a base band data signal, a first means for transmitting a signal modulated by a certain carrier frequency, and said  
10   signal being divided in the time domain into several time slots of which one transmits the common control channel (BCCH) of the base station equipment and the other time slots information regarding different connections, and an antenna, characterized in that the  
15   equipment further comprises a second means for transmitting a signal modulated by a carrier frequency, elements for changing the carrier frequency used in the second means time-slot-specifically, and means for distributing the base band signal to the first and the  
20   second transmitting means so that the signal transmitted by the second means is divided in the time domain into several time slots of which each transmits the same information as the signal transmitted by the first means except the time slot that transmits the common control  
25   channel (BCCH) of the base station equipment.

          The method of the invention can be applied for implementing frequency hopping in a cell comprising one transceiver unit. The base station in accordance with the invention can be built similarly to a conventional  
30   non-hopping base station, the only necessary changes being in the RF section of the transmitter. Only one base band section is needed. If frequency hopping is unnecessary, the base station of the invention can easily implement space diversity in a direction from the  
35   base station to the mobile station. The use of

frequencies can be optimized so that frequency hopping is utilized only on weak connections.

In the following the invention will be described in greater detail with reference to the examples in accordance with the accompanying drawings, in which

Figure 1 illustrates time-slot-specific frequency hopping,

Figure 2 shows an example of the structure of a base station equipment in accordance with the invention,

Figure 3 shows another example of the structure of a base station equipment in accordance with the invention, and

Figures 4a-4b describe the time slot construction of the output signal of the transmitting means.

The invention can thus be applied in the base station equipment of digital cellular radio systems such as the GSM system, for instance. In the following, the invention will be described when applied in a time slot structure of the type used in the GSM system, but without being restricted to that.

Figure 1 illustrates the implementation of time-slot-specific frequency hopping. The horizontal axis of the figure represents time, and the vertical axis represents frequency. The figure shows the frequency changes of one channel according to time slots. The base station changes carrier frequency at the beginning of every time slot, but the frequency is not changed during the time slot. The frequency is changed according to a predetermined sequence, in which case the receiver can monitor the hopping and receive the information contained in each time slot on a correct frequency. In a base station, each connection can have

a hop sequence of its own, in which case the frequencies used in the time slots do not overlap.

Figure 2 is a block diagram of the structure of a base station equipment in which the method of the invention is applied. The equipment contains means 15 for generating a base band signal. The output 16 of said means 15 is connected to two transmitter units 10, 18 with the aid of a base band signal divider. The first transmitter unit 10 contains a carrier generator 12 whose output 26 is connected to a modulating means 13 whose second input is a base band data signal from the base band signal divider 17. The time division carrier signal 23 modulated by a base band signal is fed via an output amplifier 14 to an antenna 11. The first signal of the transmitter unit contains the common control channel BCCH of a cell served by a base station. By listening to that signal, mobile stations obtain information of the base station so that they can contact it, if necessary. In a GSM system, traffic on the BCCH channel is transmitted in the first time slot of a frame, indicated by the number 0. The other time slots, of which there are seven in a GSM system, transmit a signal that is either data belonging to a connection or, if the time slot is not in use, is a dummy burst. Figure 4a illustrates the structure of a GSM frame in which the first time slot 0 contains the BCCH channel, the second time slot 1 a dummy burst, time slots 2, 3, 4 and 6 data information, and time slots 5 and 7 a dummy burst. The carrier frequency of the transmitter 10 is marked with  $f_1$ , and it is constant.

The second transmitter unit 18 correspondingly contains a carrier generator 20 whose output 27 is connected to modulation means 21 whose second input is the base band data signal from the base band signal divider 17, i.e. the same signal as in the input of the

first transmitter unit. In the example of the figure, the time division carrier signal 24 modulated by the base band signal is supplied via output amplifier 14 to an antenna 19. The signal of the second transmitter unit does not contain the common control channel BCCH, and the said time slot is not transmitted. In the other time slots 1-7 data belonging to some connection is transmitted, or the transmitter is switched off, if the time slot is not in use.

The carrier frequency used by the second transmitter unit hops time-slot-specifically under the control of means 25 so that with each connection (i.e. time slot) the frequency changes according to a predetermined sequence. In a base station in accordance with figure 2, in which two antennas are in use, the carrier frequency of the second transmitter unit can momentarily be the same as the frequency f1 used by the first transmitter unit.

According to a second embodiment, when both of the transmitter units are on the same frequency, the second transmitter unit is switched off to avoid simultaneous transmission.

The second transmitter unit can be controlled time-slot-specifically so that frequency hopping is only performed in certain time slots. If two antennas are in use in connections not applying frequency hopping, both transmitters transmit the same signal on the same frequency, and space diversity is obtained.

Frequency use can be optimized so that frequency hopping is only applied to poor quality connections. To judge communication quality, signal strength as well as bit error and signal-to-noise ratios can be used as standards.

Figure 3 is a block diagram representation of an alternative structure of a base station equipment



realizing the method of the invention. The equipment contains means 30 for combining signals from two transmitter units 10, 18 for transmitting via one antenna 11. The operation of a base station such as the one in figure 3 is similar to the above except that when one antenna is used, the second transmitter unit is switched off in cases where its carrier frequency is the same as the frequency of the first transmitter unit.

In addition to the components described above, the exemplary base stations also contain components other than those described, such as filters and divider amplifiers, but due to reasons of clarity they have been omitted from the figure as they are not essential to the present invention.

As explained above, figure 4a illustrates a frame structure transmitted by the first transmitter unit, the first time slot 0 containing the BCCH channel, time slots 2, 3, 4 and 6 containing data information (C1-C4), and time slots 1, 5 and 7 containing a dummy burst (B1-B3). The carrier frequency of the first transmitter is indicated by  $f_1$ , and it is constant.

Figure 4b illustrates a frame structure transmitted by the second transmitter unit. In the example illustrated in the figure, the transmitter unit utilizes three different frequencies,  $f_2$ ,  $f_3$  and  $f_4$  in frequency hopping. The number of frequencies can, of course, be something else in practice. Let us assume that connections C1, C2 and C4 using time slots 2, 3 and 6 employ frequency hopping, but connection C3 using time slot 4 does not hop. In such a case the second transmitter unit transmits a signal in time slots 2, 3 and 6 as shown by the figure, using at each moment of time one of the said carrier frequencies  $f_2$ - $f_4$ . The second transmitter unit can, depending on the application, also use the frequency  $f_1$  of the first

transmitter unit. The frequency used at each connection and each moment of time depends on the chosen hopping sequence which is specific for each connection.

5 The second transmitter unit can, for example, transmit a frame in accordance with figure 4b so that time slot 2 uses frequency f2, time slot 3 frequency f3 and time slot 6 frequency f4. In the next frame the time slots are changed so that time slot 2 uses frequency f3, time slot 3 frequency f4 and time slot 6 frequency f3.  
10 The frequencies of the time slots are independent of each other, and they can also be the same.

When two separate antennas are used, the second transmitter unit is able to transmit on non-hopping connections the time slot in question on the same  
15 frequency as the first transmitter unit in which case space diversity is achieved at the transmitting end. In the example above, the second transmitter unit can thus transmit the signal of connection C4 in time slot 4 on a frequency f1.

20 Even when using two separate antennas the second transmitter unit can be switched off if the frequencies of the transmitter units are the same; this can be done to avoid simultaneous transmission.

25 Even though the invention has been described in the above with reference to the examples in accordance with the accompanying drawings, it is obvious that the invention is not restricted to them but can be modified in a variety of ways within the scope of the inventive idea disclosed in the attached claims.  
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## Claims

1. A base station equipment in a digital cellular radio system, said equipment comprising means (15) for generating a base band data signal (20), a first means (10) for transmitting a signal (23) modulated by a certain carrier frequency, and said signal being divided in the time domain into several time slots of which one transmits the common control channel (BCCH) of the base station equipment and the other time slots information regarding different connections, and an antenna (11), characterized in that the equipment further comprises a second means (18) for transmitting a signal (24) modulated by a carrier frequency, elements (25) for changing the carrier frequency used in the second means (18) time-slot-specifically, and means (17) for distributing the base band signal (20) to the first and the second transmitting means (10, 18) so that the signal transmitted by the second means (18) is divided in the time domain into several time slots of which each transmits the same information as the signal transmitted by the first means (10) except the time slot that transmits the common control channel (BCCH) of the base station equipment.

2. An equipment as claimed in claim 1 characterized in that the first and the second means (10, 18) comprise means (12, 20) for generating a carrier wave, means (13, 21) for modulating the carrier wave by a base band signal, and means (14, 22) for amplifying the modulated signal.

3. An equipment as claimed in claim 1, characterized in that the equipment

comprises a second antenna (19) which is connected to the amplifier means (22).

4. An equipment as claimed in claim 1 characterized in that the equipment comprises means (30) for combining signals from two transmitters (10, 18) to be transmitted via one antenna (11).

5. An equipment as claimed in claim 1 characterized in that elements (25) change the carrier frequency employed by the second means (18) according to a predetermined sequence.

6. An equipment as claimed in claims 4 and 5, characterized in that the elements (25) switch off the second means (18) when the frequency indicated by the sequence is the same as the frequency used by the means (10).

7. A method for implementing frequency hopping in a base station of a digital cellular radio system, in which base station a first signal (23) modulated by a base band data signal (16) is transmitted on a certain carrier frequency (26), which signal is divided in the time domain into several time slots of which one time slot transmits the common control channel (BCCH) of the base station equipment and the other time slots information regarding different connections, characterized in that the base station further transmits a second signal (24) modulated by the same base band data signal (16) on a certain carrier frequency (27), which second signal (24) is divided in the time domain into several time slots, each of which transmits the same information as the first signal (23), except the time slot which transmits the common control channel of the base band equipment, and which carrier frequency (27) is changed time-slot-specifically so that

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the frequency is either the same as the carrier frequency (26) or different than that.

8. A method as claimed in claim 7, characterized in that the carrier frequency (27) is changed time-slot-specifically following a predetermined sequence.

9. A method as claimed in claim 7, characterized in that both the first and the second signal are transmitted via their own respective antennas.

10. A method as claimed in claim 7, characterized in that both the first and the second signal are transmitted via the same antenna.

11. A method as claimed in claims 7 and 10, characterized in that if the carrier frequency (27) indicated by the sequence and used by the second signal is the same in each time slot as the carrier frequency used by the first signal (26), the second signal is not transmitted.

12. A method as claimed in claim 7, characterized in that the second signal (24) is transmitted time-slot-specifically when the quality of the signal transmitted in the time slot is at the receiving end poorer than a predetermined threshold value.

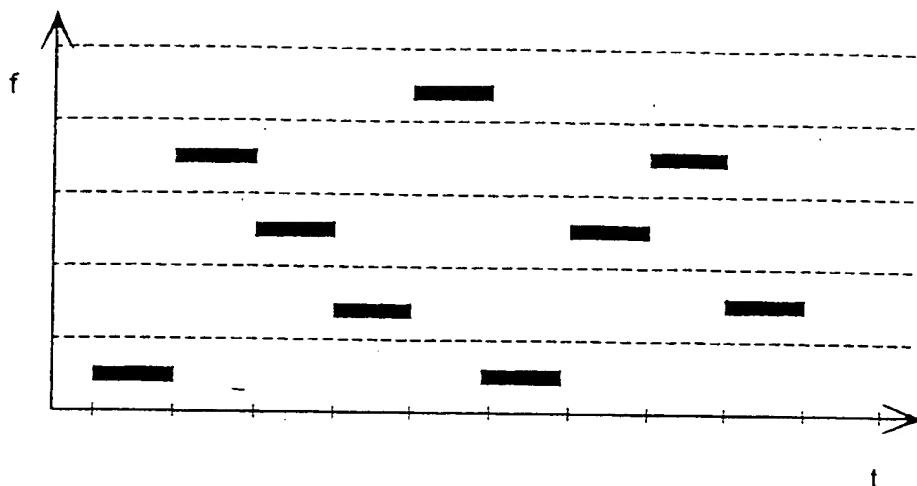


FIG. 1

	0	1	2	3	4	5	6	7
f1	BCCH	B1	C1	C2	C3	B2	C4	B3

FIG. 4a

	0	1	2	3	4	5	6	7
f2	-	-	C1	C2	-	-	C4	-
f3	-	-	C1	C2	-	-	C4	-
f4	-	-	C1	C2	-	-	C4	-

FIG. 4b

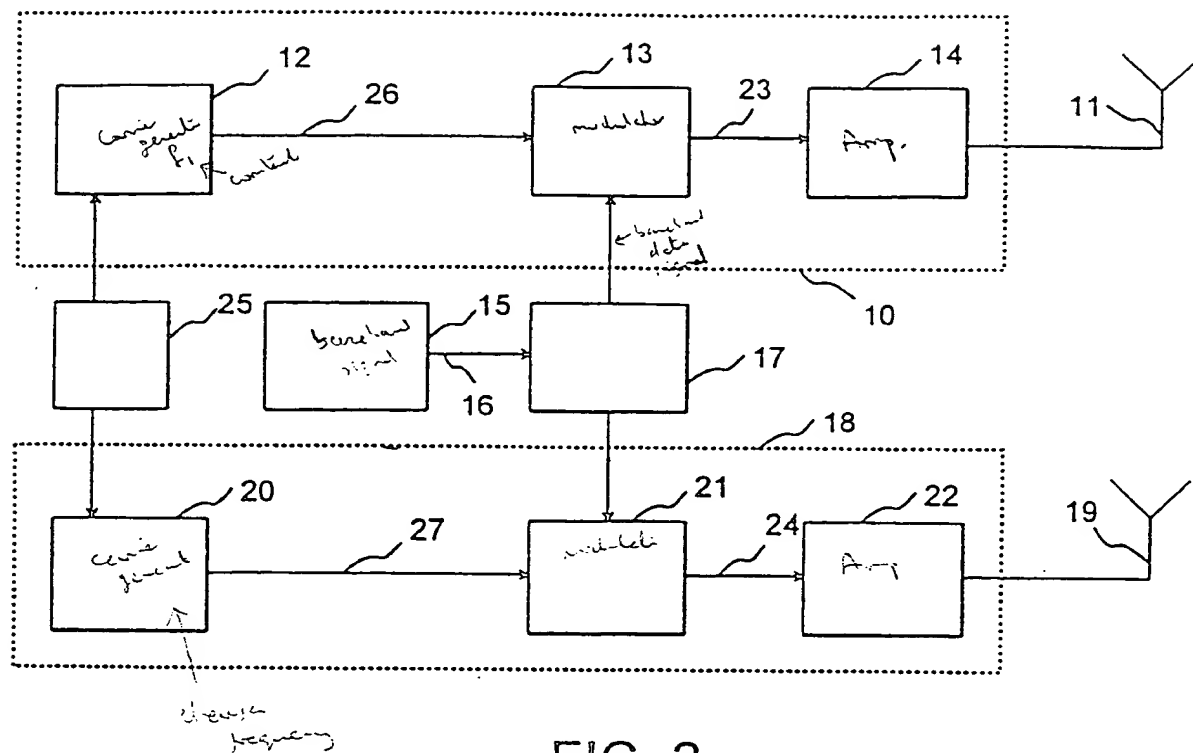


FIG. 2

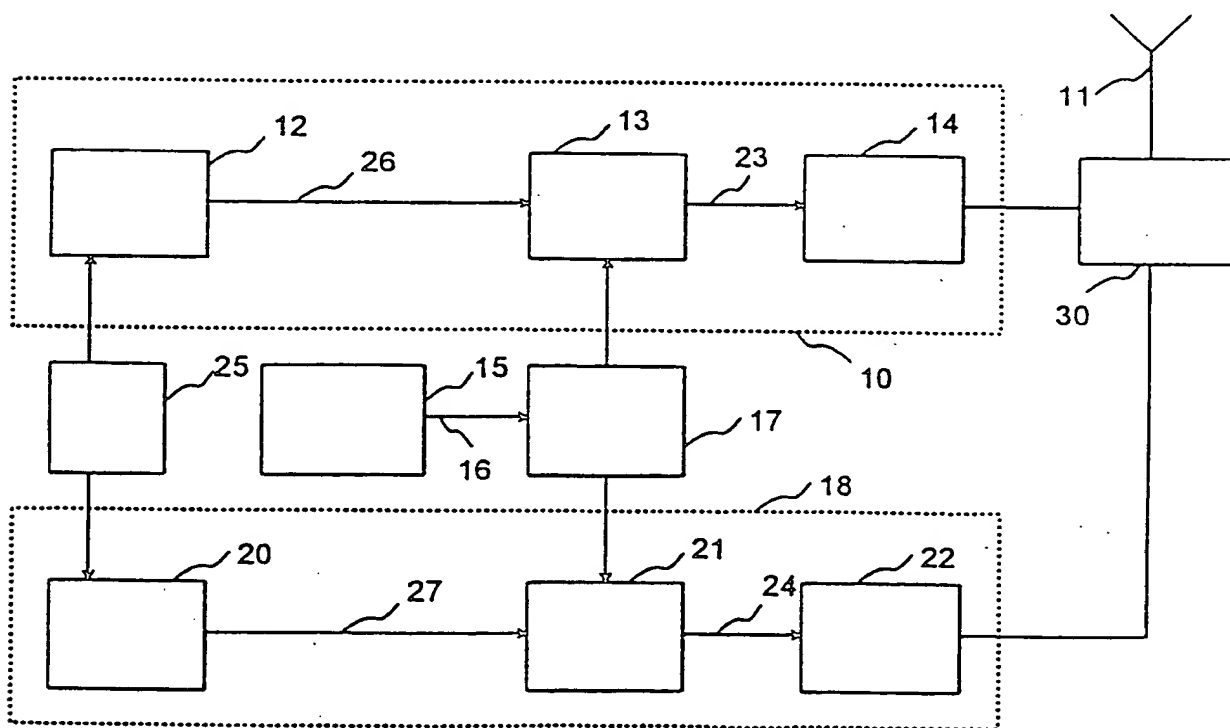


FIG. 3